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(54) **Surgical instrument for clearing arteries.**

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In order to clear obstructed arteries, it may be useful to have an instrument that is capable of being introduced between the arterial wall and the core of the obstruction, then to progress to the desired location and perform the sectioning and removal of the obstruction.

Such an instrument is the object of this invention, characterized by the inclusion of: a peripheral, extendable part that is capable of withdrawing the arterial wall from the obstruction in order to create cleavage, a tool that can advance between the arterial wall and the obstruction, and a device that makes it possible to section and remove the obstruction.

Depending on the other characteristics of the present invention, the control of the extension of the peripheral and the control of the movement of the tool are obtained via variations in fluid pressure, using external connection tubes for the instrument. In such an embodiment, the extendable peripheral part consists of an inflatable pouch which separates the splints, and the tool forms a unit with a piston. The obstruction may be sectioned by using a cutting blade, which is introduced from the exterior by way of a flexible rod. The extension of the peripheral section, the movement of the tool, and the sectioning device are may be controlled mechanically and externally by way of a flexible cable comprised of a sheath and a central core which, in relation to one another, are mobile in translation. In this new embodiment, the extendible peripheral part is comprised of splints which are pushed with a flexible cable onto the sliding routes of the tool and oriented outwards. The extremities of the splints provide for the sectioning of the obstruction. The flexible cable is used to remove the splints from the sliding routes oriented outwards, either by using a translation movement only or by using a translation movement and a rotation movement.

An envelope made of plastic material is placed behind the instrument to receive the obstruction and facilitate its extraction following the sectioning procedure.
Examples for implementing this invention will be described in a non-exhaustive manner and refer to the figures in the diagrams below.

Fig. 1 shows a surgical instrument in conformity with the present invention, the movements of which are controlled by variations in fluid pressure.

Fig. 2 and Fig. 3 show, in two different positions, the splints used in the instrument shown in Fig. 1.

Fig. 4 is on overview of the instrument shown in Fig. 1.

Figures 4 to 9 diagram the method for advancing the instrument within an artery in conformity with the present invention.

Fig. 10 shows a surgical instrument equipped with a plastic material envelope intended to receive the obstructions.

Figures 11 to 14 show the different possible forms for a surgical instrument in conformity with the present invention.

Fig. 15 shows a surgical instrument in conformity with the present invention, the movements of which are controlled mechanically by way of a flexible cable.

Fig. 16 shows a grip that makes it possible to control the instrument shown in Fig. 15.

Figures 17 to 19 diagram the operating method for the instrument shown in Fig. 15.

Figures 20 and 21 show another surgical instrument in conformity with the present invention, the movements of which are controlled mechanically via a flexible cable.

The surgical instrument shown by Fig. 1 is controlled by fluid pressure. It consists of a cylindrical body 1, in front of which a tool 2, which forms a unit with a piston 3, may be moved via the action of fluid pressure exerted from the exterior by the intermediary of a channel 4. An inflatable section 5 is provided around the body 1. Its volume depends on the fluid pressure exerted from the outside via the intermediary of the channel 6. Winglets 7, placed on the periphery of the instrument, can be withdrawn on the side of the tool 2 via the inflatable part 5. On the side opposite to the tool 2, the winglets are attached to the body 1. A cutting blade 8 may be placed inside of the body 1. It comes out of its housing 9 under the action of pressure exerted from the exterior via a rod 10.

Figures 2 and 3 show, in two different positions, a unit of winglets 7 that may be used on the instrument shown by Fig. 1.

Fig. 4 is an overview of an instrument in conformity with the present invention, such as the one shown by Fig. 1, and

equipped inside with a handling rod within which channels 4 and 6 pass through, as well as the control rod 10.

It will be easier to understand how to use the present instrument by referring to Figures 5 to 9.

As shown in Fig. 5, the surgeon introduces the instrument inside of the artery to be cleared. When the cleavage between the wall of the artery and the obstruction to be removed has been achieved, it is possible to introduce the tool 2 by having it withdrawn by using fluid pressure. To facilitate the advancement of the tool in the cleavage, it is necessary to separate the wall from the obstructed artery. Thus, the winglets 7 must be spread, as shown by Fig. 7. The complete advancement of the tool 2 is now possible. When the advancement of the tool 2 has been made, the wings 7 are brought back along the length of the body as shown by Fig. 8. The surgeon then advances the instrument for a length equal to the course of tool 2, with the position in Fig. 9 being identical to that in Fig. 5. The progression operation may begin again. The surgeon can directly control the different operations, but there could also be an automatic installation. The movement of the piston may be a vibration movement which can facilitate the separation of the wall from the deposits. When the instrument has advanced a sufficient length, the surgeon activates the cutting blade 8, which makes it possible to cut the obstruction by applying a rotation movement to the instrument.

Fig. 10 shows an instrument behind which an envelope 12 of plastic material has been affixed. Its purpose is to facilitate the extraction of the obstruction.

The winglets 7 can be removed and replaced by the wall of the inflatable part 5; the latter may, for example, be made of rubber.

Because of the elasticity of the arterial wall, the instrument just described adapts to the changes in the arteries' diversions. When this adaptation is not sufficient, instruments of different shapes may be used. Fig. 11 shows an instrument that is in the shape of a half-ring, and Fig. 12 shows an instrument comprised of two half-rings connected to each other in a more or less elastic manner, and Fig. 13 an instrument in the shape of an unclosed ring. It is also possible, as shown in Fig. 14, to place an inflatable part and winglets in the cavity located inside the body of the instrument.

The surgical instrument depicted in Fig. 15 is operated mechanically and meets the same requirements as the water pressure-operated instrument. This instrument consists of a cylindrical body 13 whose size is based on the diameter of the artery to be operated on. At the extremity of the cylindrical body 13 is a toric end piece 14 carefully rounded towards the front. The end piece 14 has independent channels leading to the exterior and the interior of the flow paths 15 and 16. A certain number of splints 17 shaped so as to not cause injury are placed at the periphery of the instrument. These pallets are maintained by a toric axle 18 around which they may turn, and an elastic ring 19 keep them against the body of the instrument without impeding their movements. Connecting rods 20 connected to a ring 21 which can slide onto the cylindrical body 13 are what cause the alternative longitudinal movement of the splints 17. The connecting rods 21 are connected to the splints by the toric axle 18. An appropriately tared spring 22, placed between the slide ring 21 and a ring 23 that forms a unit with the body 13 maintains the instrument in the resting position. The instrument is controlled from the outside by using a cable with a flexible sheath that forms a unit with the slide ring 21 and a flexible core 25.

Lights 26 are provided for in the cylindrical body 13. They make it possible for the splints 17 to penetrate the interior of the cylindrical body.

The other extremity of the cable is connected to a control grip, shown in Fig. 16.

The body 27 of the grip forms a unit with the sheath 24 of the flexible cable while the mobile part 23 forms a unit with the core 25 via an adjusting screw and a stop piece 30. A retractable stop 31 limits the closure of the grip to a determined size.

In order for it to be introduced into an artery, the instrument is placed in the position of Fig. 15. By maneuvering the command grip, the slide ring 21 and the connecting rods 20 are pushed forwards. The splints bear on the sliding routes 15 and become situated in the positions shown in Fig. 17. In this position, the extension of the arterial wall causes it to separate from the obstruction. When slackening the grip, the spring 22 makes the body 13 move forward while the splints 17 close to resume their initial position. The repetition of these movements allows the instrument to progress inside of the artery.

Once the instrument has arrived at the appropriate place to perform the sectioning of the obstruction, the stop 31 is retracted so that the splints, under the effect of the spring 22, escape to the sliding routes 15 and are situated, as shown by Fig. 18, in contact with the sliding routes. The retractable stop 31 can be put back into place.

By maneuvering the grip as described above, the splints cross the body 13 with the help of the lights 26, folding in on themselves in the position shown in Fig. 19. The extremities of the splints provide for the sectioning of the obstruction, which they trap. The entire instrument just needs to be withdrawn in order to remove the obstruction blocking the artery.

Fig. 20 shows another form of the embodiment of the mechanically controlled surgical instrument. Over the course of the progression, the splints 17 are no longer situated across from the lights 26. In this scenario, a rotation of the splints 17 in relation to the body 13 is necessary in order to section the obstruction. The end piece 14 of the tool is machined in such a way that it presents a slope 32 to the splints 17 during the progression and a slope 33 at the time of sectioning. This latter slope is across from the light 26. The splints 17 are articulated around an axis 34 that forms a unit with a mobile cylinder 36 which can slide onto the body 13. A spring 37 is situated between the mobile cylinder 36 and a fixed ring 38. A flexible cable provides for the connection with the control grip 25. The sheath of the cable forms a unit with the fixed ring 38 and the core of the cable forms a unit with the mobile cylinder. As shown from above in Fig. 21, the mobile part 36 is guided in its movement by a spur 39 which slides in a light 40. A stop situated on the control grip, for example between parts 27 and 28, can limit the opening of the grip so that the spur 39 does no reach the level of the light 41 perpendicular to the movement. On the other hand, this position must be achieved in order for the splints to move as activated by the spring 37 that is attached at its extremities 42 and 43 to parts 38 and 36, respectively. In this new position, the splints are placed across from the lights 26 and the sliding routes 33 and the sectioning procedure is authorized.

SUMMARY

1) The object of the present invention is a surgical instrument to clear obstructed arteries. It is able to progress within an artery to separate an obstruction from the artery wall and extract the former. It is characterized

in that it has an extendable peripheral part which can separate the artery wall from the obstruction to create cleavage, a tool that can progress between the artery wall and the obstruction, and a device that makes it possible to section the obstruction and extract it.

2) In an instrument as per 1), the control for the extension of the peripheral part and the control of the tool's movement are obtained by variations in fluid pressure from tubes providing a connection to the instrument from the outside.

3) In an instrument as per 1) and 2), the extendable peripheral part is comprised of an inflatable pouch which separates the splints.

4) In an instrument as per 1) and 3), the tool forms a unit with a piston.

5) In an instrument as per 1) to 5), a cutting blade, pushed from the outside by way of a flexible rod, is used to section the obstruction.

6) In an instrument as per 1), the control of the extension of the peripheral part, the control of the movement of the tool, and the control of the obstruction sectioning tool are provided by a flexible cable comprised of a sheath and a central core which are mobile in translation in relation to one another.

7) In an instrument as per 1) and 6), the extendable peripheral part is comprised of splints that are pushed, by using a flexible cable, onto the sliding routes of the tool that lead to the outside.

8) In an instrument as per 1), 6), and 7), the sectioning of the obstruction is provided via the extremities of the splints which, by way of the flexible cable, are removed from the sliding routes oriented externally and pushed onto the sliding routes of the tool leading inside.

9) In an instrument as per 1) and 6) to 8), the splints are removed from the sliding routes oriented towards the outside, either by a translation movement alone or by a translation movement and a rotation movement.

10) In an instrument as per 1) to 9), a plastic material envelope receives the obstruction and facilitates its extraction following the sectioning procedure.

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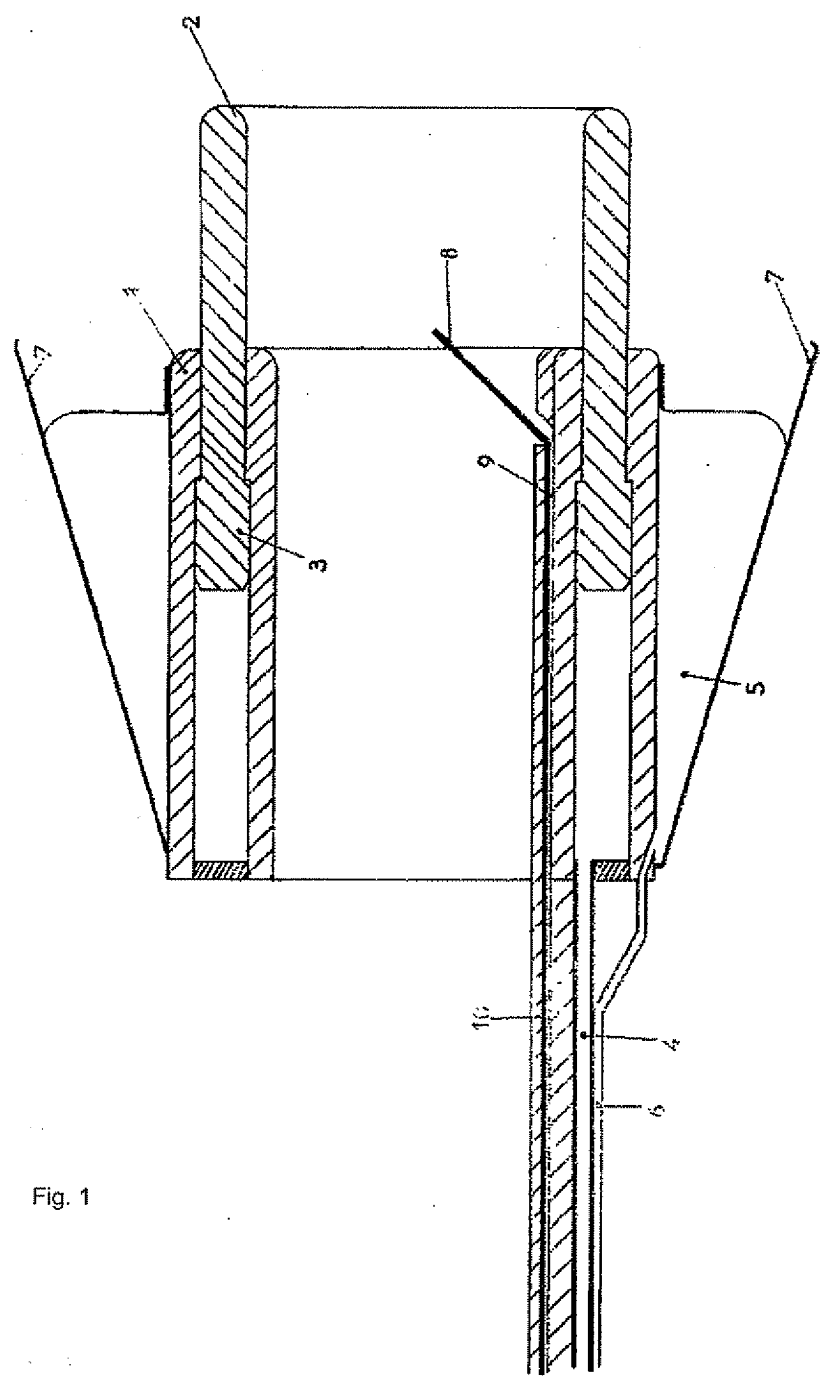


Fig. 1

Fig 2

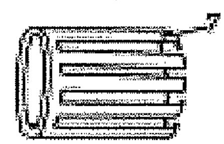


Fig 3

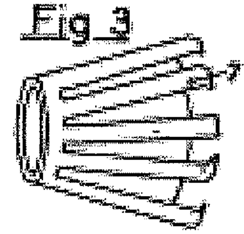


Fig 10

Fig 11

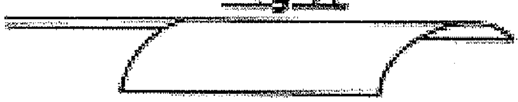


Fig 14

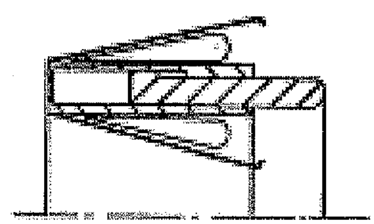


Fig 12

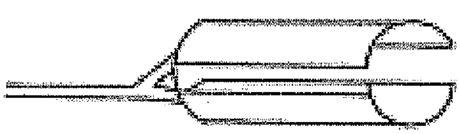


Fig 13

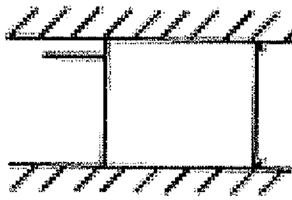


Fig 5

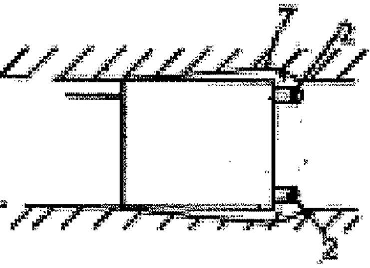


Fig 6

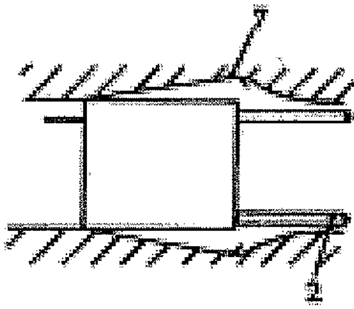


Fig7

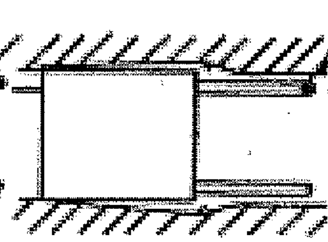


Fig8

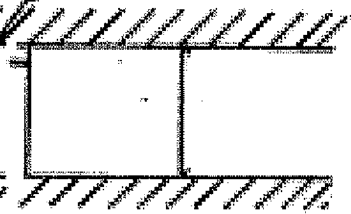


Fig 9

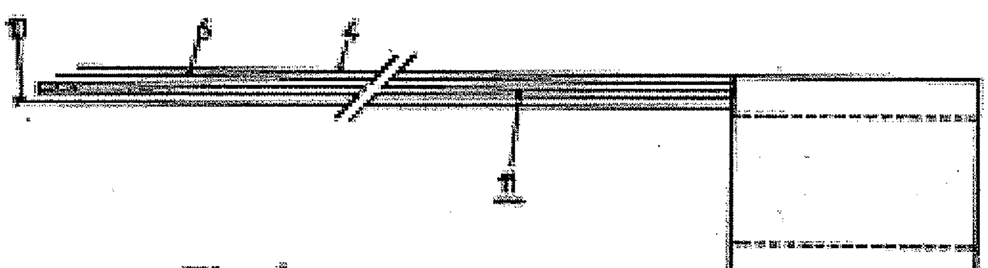


Fig 4

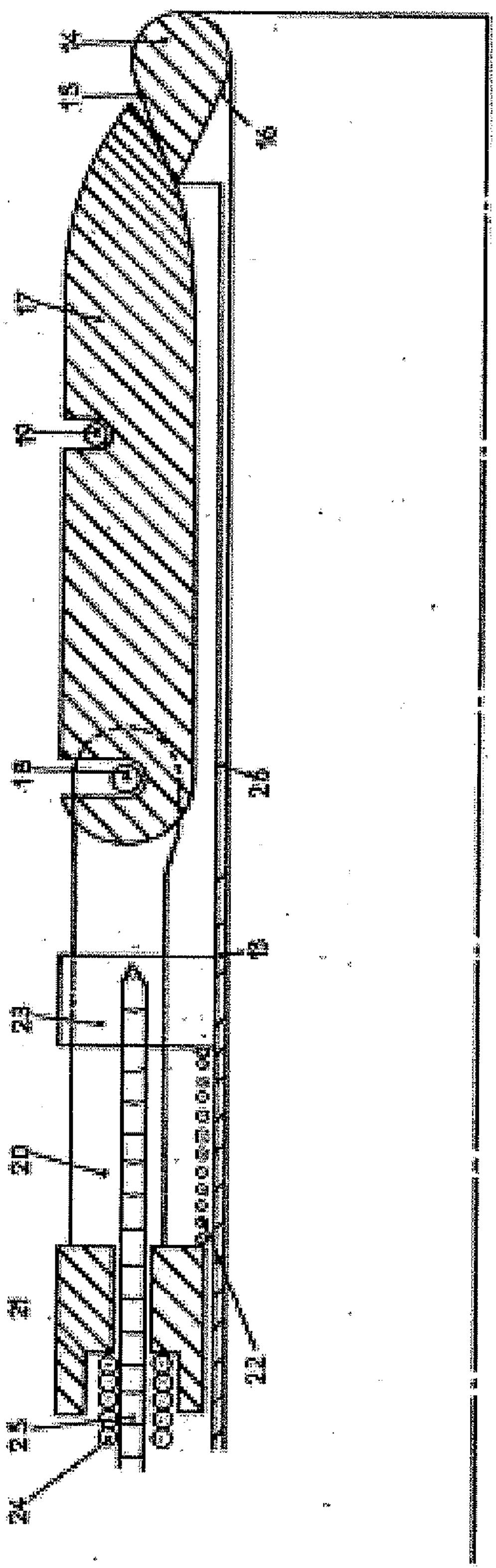


Fig 15

Fig 16

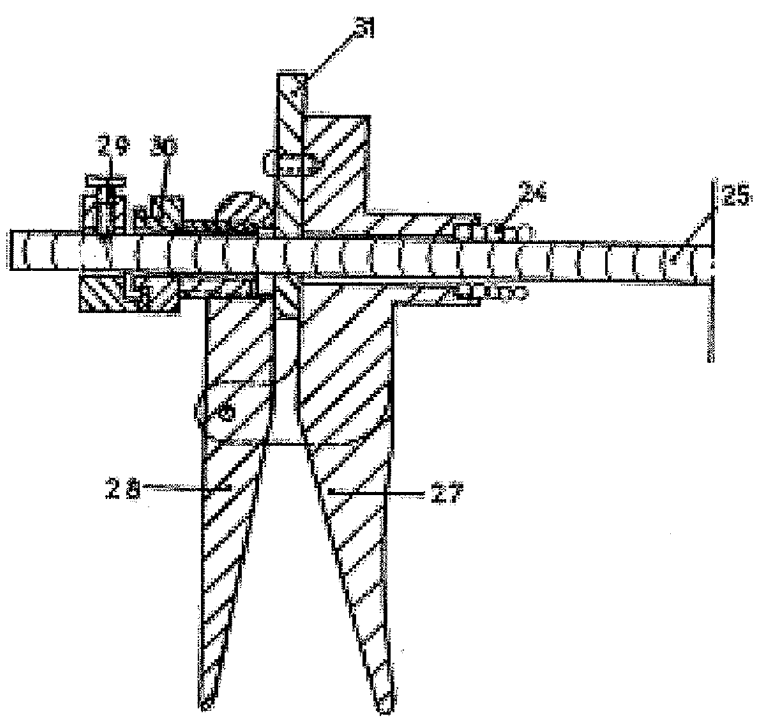
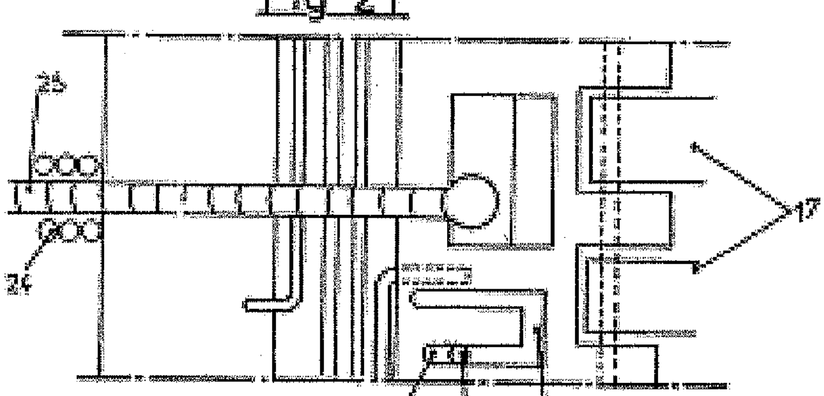


Fig 21



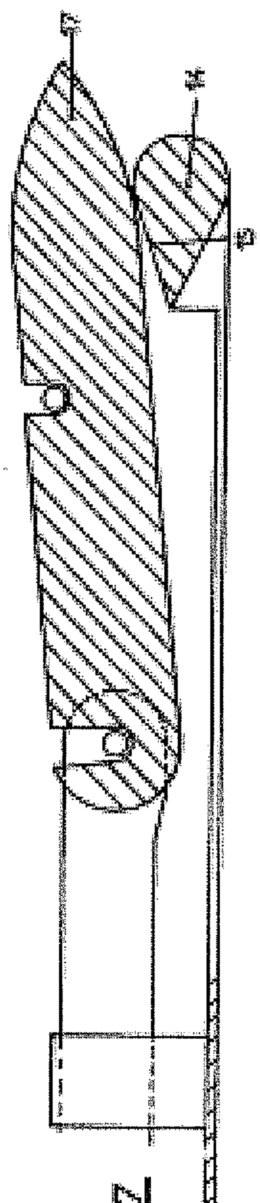


Fig 17

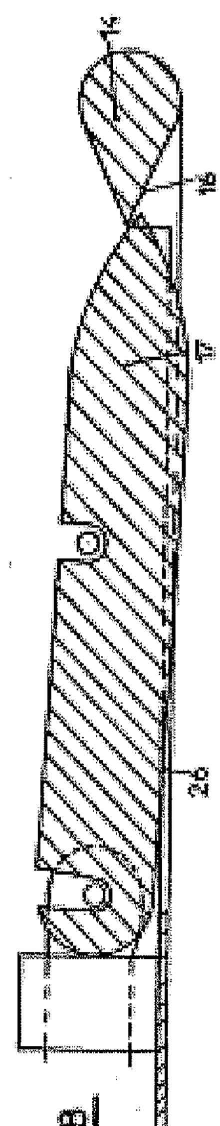


Fig 18

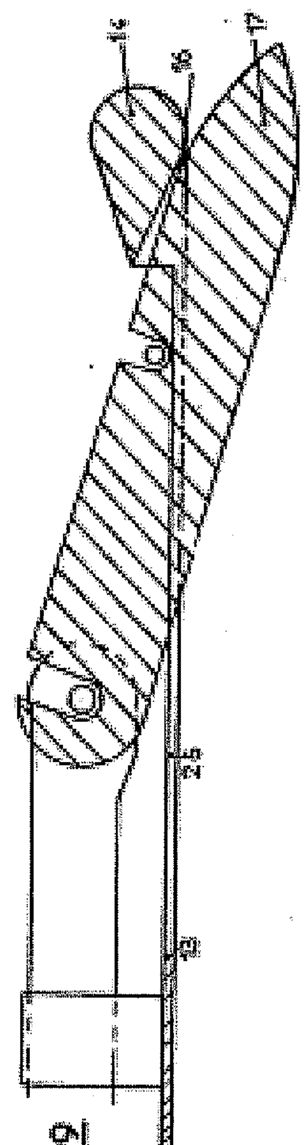


Fig 19

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PL. VII-1

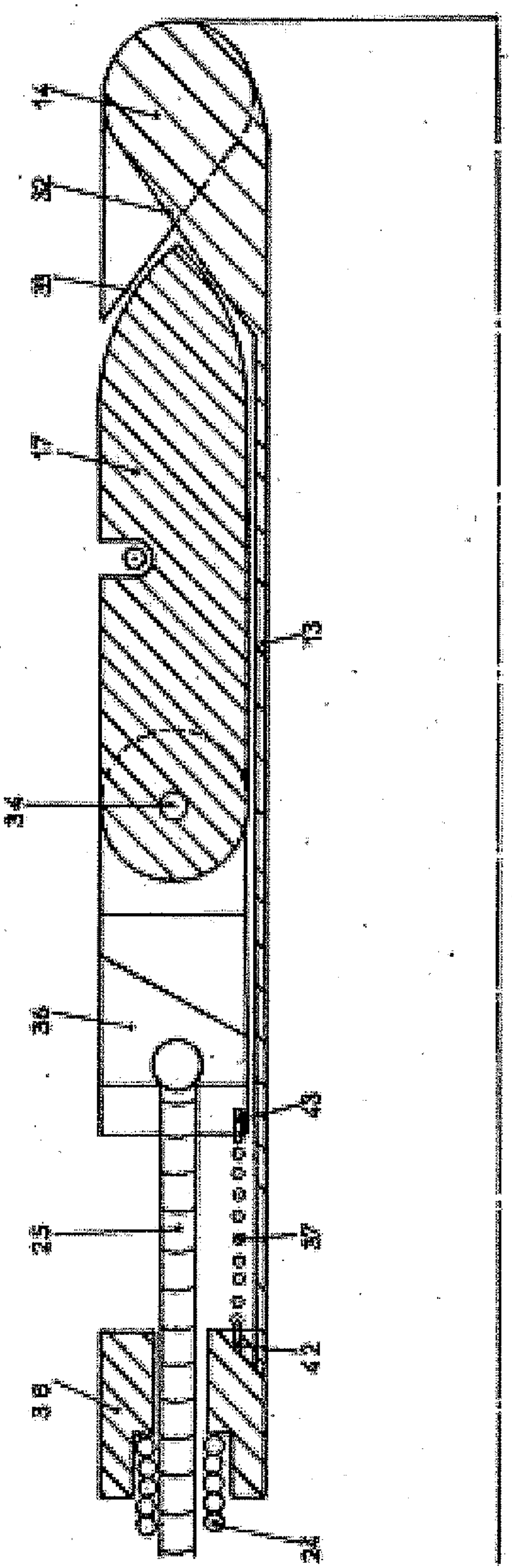

Fig 20